Earth Surface Processes and Landforms
Earth Surf. Process. Landforms **23**, 1135–1139 (1998)

SHORT COMMUNICATION

DISCUSSION: DENUDATION RATES IN SOUTHEAST NORTHUMBERLAND SINCE THE DEVENSIAN GLACIATION

RICHARD CLARK*

Parcey House, Hartsop, Penrith, Cumbria, CA11 0NZ, UK

Received 4 February 1998; Accepted 4 July 1998

ABSTRACT

Field examination and review of previous studies show that glacial landforms are widespread in southeast Northumberland and across the local altitude range. Ice-contact deposits occur on the main valley floors. Numerous subglacial channels descend to or close to present valley floors, and many of the lesser valleys have carried meltwater and glaciofluvial sediment. In major part, the land surface retains its end-glacial form and age. Evidence for a landscape largely end-glacial in form and age rather than one produced since loss of ice cover by laterally diverse erosion indicates that rates of denudation over the last 15 ka have been less than those obtained from height differences between actual surface and a reconstructed notional end-glacial surface. © 1998 John Wiley & Sons, Ltd.

KEY WORDS Northumberland; glacial landforms; age of landsurface; rates of denudation

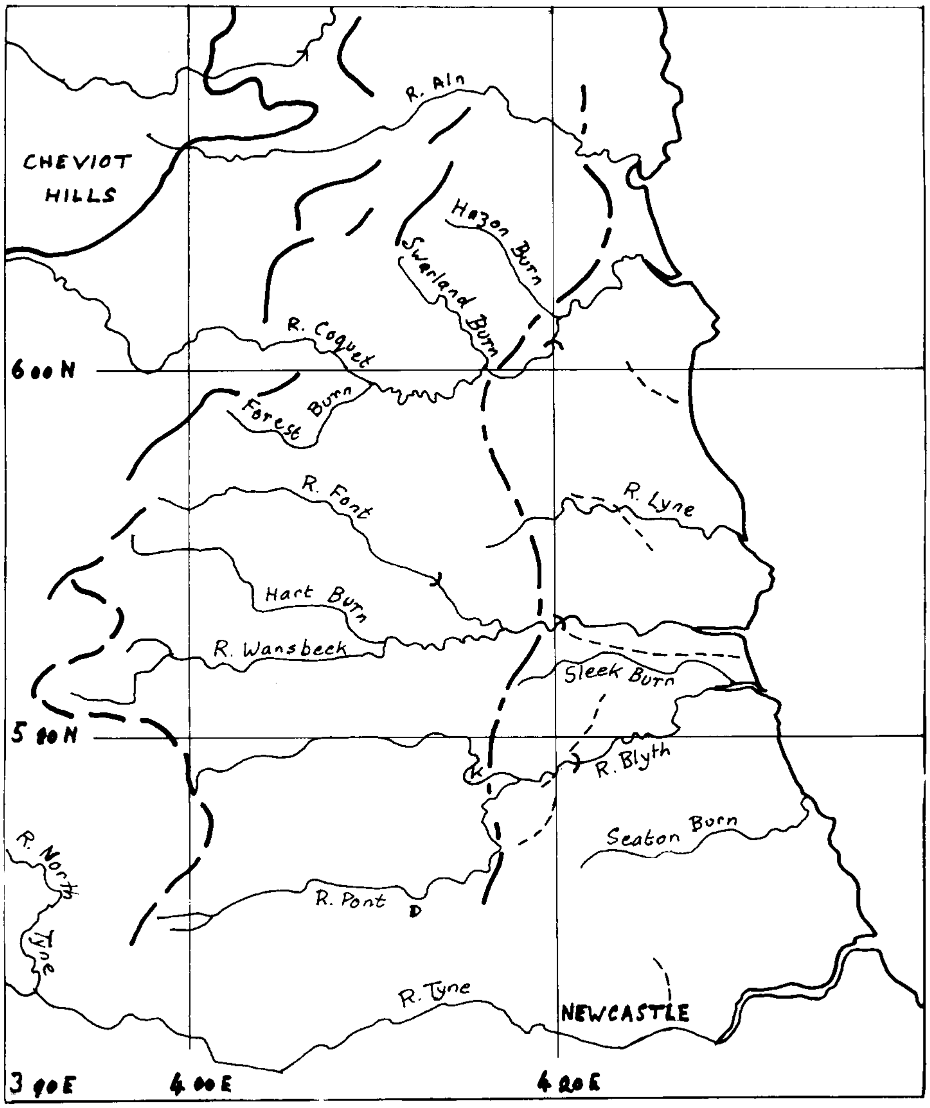
Clayton's (1997) assessment of denudation rates on some British lowland landscapes raises questions about the application of the methodology to and the results obtained from southeast Northumberland. As the discussion refers to several localities there, a brief introduction to the area portrayed in Clayton's figure 3 follows (Figure 1).

The southern boundary (Grid Line 5/80 N) runs east along low ground of the River Blyth and its tributaries. A little to the north of the boundary, the Blyth crosses the coastal plain in a narow incision into bedrock and is joined in its estuary by the Sleek Burn, rather less incised. The Sleek Burn catchment and that of Seaton Burn, south of the Blyth, are wholly on the coastal plain. The River Wansbeck which runs east to the coast (at 5/85 N) from its watershed with North Tynedale (4/00 E) receives two main left-bank tributaries, the Hartburn (at 4/11 E) and the River Font (at 4/17 E). The River Lyne is the main stream in the area defined on Clayton's figure 3 as one 'where rivers rise on the till surface': it rises at 4/16 E and reaches the coast at 5/91 N. The valley with large deviations below the reconstructed original till surface is that of the River Coquet, entering the map area from the northwest near 4/00 N. It then trends ENE to the sea near 6/05 N. It is joined from the southwest by the Forest Burn and also by several left-bank tributaries, principally Swarland Burn and Hazon Burn. These latter run down the dipslope of those Fell Sandstone cuestas which, culminating beyond the area mapped in Clayton's figure 3, separate Coquet and Aln catchments. The Aln flows east just north of the mapped area which, however, includes part of its catchment. Like the Coquet, it crosses the vale that separates the Cheviot Hills from the Fell Sandstone cuestas, and, like the Coquet, it passes through them in a deeply-cut valley. Some of the characteristics of the Aln valley are material to this discussion. The Coquet, Wansbeck and Font valleys west of the coastal lowland are portrayed by Clayton as those parts of the study area most lowered below the reconstructed datum surface and thus they merit particular attention as, for the same reason, does the Aln valley to the north.

Clayton stressed (p. 724) that understanding of landform development depends on adequate

* Correspondence to: Dr R. Clark, Parcey House, Hartsop, Penrith, Cumbria, CA11 0NZ, UK

CCC 0197-9337/98/121135–05 $17.50



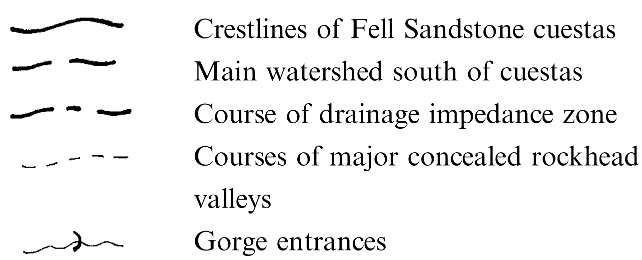


Figure 1. Map to show locations of the principal features referred to in the text

chronologies and reliable knowledge of rates of landform change. If the original form and age of a land surface can be determined then present deviations from it, and the time elapsed, permit statement of amounts and rates of change and their spatial distribution. The 'dissected till surfaces of East Anglia and northern, coastal Northumberland [the] latter surface – deposited during (or – at the end of) the maximum stage of the Devensian Glaciation, c. 15 ka BP' were taken as areas for which original as-deposited surfaces can be reconstructed. A recent comprehensive review of the Quaternary in northeast England (Lunn, 1995, p. 310) noted that there is 'scant evidence on which to base estimates of magnitude' of landscape change at any time during its development.

The generalized contours of Clayton's figure 3 portray the reconstructed end-glacial surface. They are projected from 'the highest points of the interfluves [where] constructional glacial forms persist' (Clayton, 1997, p. 726) to show a series of shallow valleys and embayments above the present land surface. Distances between reconstructed and present land surfaces measure denudation during the last 15 ka. For the greater part of the area assessed, denudation is less than 11 m: amounts of erosion approaching that figure could well change the detailed appearance of the end-glacial landscape. Along major valleys, depths of erosion are shown to exceed 45 m extensively and to be over 60 m in part of the Coquet valley.

Clearly, measures of postglacial denudation derived from the two surfaces depend for validity on the propriety of assumptions about the surfaces: comparison with assessments of denudation from the Suffolk case is consequentially dependent. If one surface substantially conforms to the end-glacial landscape, the other, except where the two are in very close proximity, cannot. One surface is notional: it reflects a constrained choice of what relief the reconstructed surface should be given. The other surface is accessible: the assumption that, except at highest points on the interfluves, it significantly deviates from the end-glacial surface is now examined. Much relevant evidence comes from the work of meltwater that moved both into the area and between various catchments within the area. Many of the limited exposures of rock through valley floor till and sand–gravel deposits can be related to erosion by meltwater: most valleys, the deepest included, are drift-lined rather than cut through drift. Circumstances that influenced the flow of meltwater and carriage of glaciofluvial material in northeast England were reviewed by Lunn (1995). Evidence is ubiquitous for the passage of subglacial meltwater, either constrained by ice cover, or freely down subglacial hillsides and along floors of existing valleys. Lunn noted the 'many hundreds of channels in the region' formed in the latter way.

Southeastern Northumberland is divided along a north–south zone, not straight but generally near easting 4/20 E. Relief is stronger on the higher western ground and ice movement there was to the east, as was most movement of meltwater. The subdued relief of the coastal lowland in the east is, however, diversified by many north–south meltwater channels including those across catchment boundaries. There are many deposits of glaciofluvial material associated with these channels, and extensive spreads of sands and gravels in the partition zone. Smythe (1908) noted from the River Blyth sector of the zone, that at Dissington (45/120 700, D in Figure 1) sand–gravel mounds contain mainly western materials and those nearby at Kirkley Hall (45/150 770, K in Figure 1) have northern, including Cheviot, lithologies. Lunn (1995, p. 308) referred to the line of division as the 'assumed suture zone of western and northern ice' where 'meltwater drainage impedance was to be expected' and Clark (1970, p. 136) described it as an 'inner limit of influence of coastal ice.'

Along the western margin of the present area, from its southern boundary to the headwaters of the River Font, there are many col channels, here interpreted as routes by which meltwater moved east from North Tynedale. Several lead directly into upper valleys of the Blyth and Wansbeck catchments. Strings of glaciofluvial mounds on the North Tynedale side lead up to cols and there are scattered sand–gravel mounds in upper valleys of the eastern catchments. There are several impressive incisions to bedrock in cols on the crest of the cuesta northwest of Clayton's mapped area. Many melt discharge channels there lead east into tributary valleys of the Forest Burn and the River Font where there are many discrete mounds of glaciofluvial material. There are also sand and gravel spreads up to 1 km in width in and near the low col (44/050 940) on the Coquet–Font watershed: this col is taken to have been a major meltwater

route. In both main and larger tributary valleys meltwater inputs and glaciofluvial sediments are concentrated on lower valley sides and also valley bottoms, onlapped by modern alluvium. Further north, meltwater input routes from the Aln to the Coquet catchment lie between 260 and 90 m OD: in several cases meltwater channels lead directly into upper left-bank valleys of the Coquet. Lowest meltwater input routes to the area, 30–60 m OD and close to the coast, led water southwest up the present lower valley of the Coquet: eastward meltwater movement was apparently inhibited when that took place.

Internal transfers of meltwater are significant in that they, too, include cases of ice-constrained water movements affecting present drainage pattern and surface form, i.e. before 'the starting time' for denudation and incision. The main ones are noted by location and direction of transfer. North of the Coquet, a col (150 m OD, 46/117 019) led water from the valley of Swarland Beck to the main Coquet valley, and adjacently (180 m OD, 46/100 001) there is a cross-slope channel with glaciofluvial mounds high on the northern side of the Coquet valley. These and other features high on the cuesta dipslope suggest contemporary impediment to direct downslope movement of meltwater, presumably earlier than the constraint exercised in the proposed 'suture zone' further east.

Between Coquet and Wansbeck, cases of internal transfer include minor links between right-bank subcatchments of the Coquet. A Coquet to Font transfer site (135 m, 45/136 926) leads into a valley floor on the Font side, and a Font to Lyne link, crest at 45/158 902, is marked by an 'up-and-over' chain of glaciofluvial deposits including at floor level in a headwater valley to the Lyne. On the coastal plain (45–75 m OD), south-directed meltwater transfer routes from Coquet to Lyne catchments are associated with glaciofluvial deposits to and across present valley floors. These may have formed in a late phase in the glaciation when eastern ice still inhibited eastward movement of meltwater in the lower Coquet valley (Lunn, 1995) and form part of a set of landforms associated with southward movement of meltwater.

Col channels cross the Wansbeck–Blyth divide at 105 m and 60 m, the latter possibly associated with the Coquet–Lyne transfers noted above. The ridge separating Blyth and Tyne basins is also crossed by small col incisions, some of which lead to present valley floors, but there is no major transfer route south to the Tyne basin west of 4/25 E. Anson and Sharp (1960, p. 7), also, recorded occurrence on the coastal plain of 'shallow "through" north–south channels generally associated with masses of sand and gravel'. One of their two examples (45/211 950) is on the Coquet–Lyne watershed and there is some indication that water input from the north continued after passage of water south from Lyne to Wansbeck (4/22–4/25 E) had ceased. The other (45/278 780) took water south across the Blyth–Seaton Burn watershed. Overall, the number and distribution of transfer points, associated glaciofluvial deposits and relationships with present valleys indicate that significant parts of the present stream pattern and relief developed in the presence of ice capable of constraining courses of meltwater flow.

The main rivers, Coquet, Wansbeck and Blyth, cross the coastal lowland in narrow gorges cut through drift to or into bedrock. These incisions have customarily been regarded as postglacial (e.g. Anson and Sharp, 1960; Cumming. 1971). Their entrances are in the vicinity of 4/20 E, in the 'suture zone'. Spreads of glaciofluvial sands and gravels lie alongside the gorges on the surface into which the gorges are cut. To the west, the valleys are open though drift encumbered. Till and sand–gravel deposits, some, as near Kirkley Hall, with ice-contact forms, line valley sides and extend on to valley floors where they are overlapped by more recent alluvium. Concealed rockhead relief east of *c*. 4/20 E (Anson and Sharp, 1960; Cumming, 1971), known from coalfield investigations, includes deep valleys that extend from the vicinities of open valley–gorge transitions along courses that diverge from the gorges. Height relationships among these features are exemplified from the Blyth valley. At valley transition, *c*. 4/216 E, upstream alluvium surface and gorge entrance are both close to 40 m OD. For *c*. 11 km upstream the river flows on drift. Downstream it is on rock to tidewater. Under the alluvial reach at gorge entrance, rockhead in the centre of a concealed valley is below present sea level. The shoulder of gorge incision is at 45–50 m in the west falling to *c*. 30 m near the coast. North of the gorge, the base of sand–gravel exposures falls from 75 m to about 40 m (west to east), the gorge being cut into a shallow depression in the till surface. Neither convincing evidence nor adequate circumstances for postglacial gorge initiation

have been proposed. The nature of, and relationships among, the local features make the gorges amenable to explanation in terms of contemporary impedance of drainage and drift deposition at and east of the 'suture zone'. They are taken to augment evidence for lowland landforms having originated in the presence of Devensian ice.

The greatest depths (over 60 m) of erosion after ice loss shown in Clayton's figure 3 are in and near the gap by which the Coquet crosses the Fell Sandstone cuesta in the northwest of the area. The Aln gap would show similar depths. In each gap a rock-cut valley, more commodious than present relief suggests, is obscured by later accumulations of glaciofluvial deposits, more substantial in the Aln gap where they reach 60–75 m above the river and where thicknesses of over 30 m have been proved (Parsons, 1966). In the Coquet gap they extend to *c*. 45–60 m above the river. Within vales of both the Aln and Coquet upstream of the cuesta gaps, glaciofluvial deposits and meltwater courses extend to the floors of both main and tributary valleys and to unknown depths below the surface of alluvium. In the Aln vale, these include southward inputs from the Breamish valley (e.g. 46/100 140, 46/120 180) and east from the Coquet vale at 46/045 185 and elsewhere. Corresponding relationships are found downstream of the cuesta gaps. It seems evident that the Aln and Coquet valleys above, in and downstream of cuesta gaps had been deepened to at least present river levels before the end of occupation by ice. While the circumstances that led to build-up of sand–gravel infills in the gaps are not clear, the late discharge of meltwater from the already deepened inner vales could not have occurred without routes through the somewhat constricted gaps. In these cases, as in others, it is difficult to accept that the depths of erosion shown in Clayton's figure 3 are measures of change since loss of ice.

From across southeast Northumberland, evidence accumulates to show that the present land surface conforms closely to and better represents the end-glacial land surface than does the reconstructed surface. Consequently, figures for amounts and rates of local landscape lowering during the last 15 ka (Clayton, 1997) stand in need of downward revision.

ACKNOWLEDGEMENT

I am grateful to Dr A. G. Lunn for helpful discussions and constructive comment on early versions.

REFERENCES

Anson, W. W. and Sharp, J. L. 1960. *Surface and rockhead relief features in the northern part of the Northumberland coalfield*, University of Durham (King's College) Department of Geography Research Series, **2**.

Clark, R. 1970. 'Aspects of glaciation in Northumberland', *Proceedings of Cumberland Geological Society*, **2**, 133–156.

Clayton, K. M. 1997. 'The rate of denudation of some British lowland landscapes,' *Earth Surface Processes and Landforms*, **22**, 721–731.

Cumming, J. S. 1971. *Rockhead relief of south east Northumberland and the lower Tyne valley*, Department of Geography, University of Newcastle upon Tyne, Seminar Paper **18**.

Lunn, A. G. 1995. 'Quaternary' in Johnson, G. A. L. (Ed.), 'Robson's geology of north east England', *Transactions, Natural History Society of Northumbria*, **56**, 297–311.

Parsons, A. R. 1966. *'Some aspects of the glacial geomorphology of north-eastern Northumberland'*, unpublished MSc thesis, University of Leicester.

Smythe, J. A. 1908. 'Glacial Phenomena of the country between the Tyne and Wansbeck', *Transactions, Natural History Society of Northumberland and Durham*, **3**, 141–153.